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# ELECTRICAL CONTACT MATERIAL AND METHOD FOR MAKING SAME

The present invention relates to the field of electrical contacts. It relates more particularly to a contact material with an arc extinction effect and to its manufacturing process.

Such a type of material is mainly applicable for the production of what are called "low voltage" contacts, that is to say contacts whose operating range lies approximately between 10 and 1000 volts and between 1 and 10 000 amps. Such contacts are generally used in the domestic, industrial and automobile fields, both for DC and for AC applications, for switches, relays, contactors and circuit breakers.

When a pair of electrical contact elements under voltage opens, the current continues to flow from one contact element to the other, ionizing the gas through which it passes. This column of ionized gas, usually called an "electric arc", has a maximum length that depends on various parameters such as the nature and the pressure of the gas, the voltage across the terminals, the contact material, the geometry of the equipment, the impedance of the circuit, etc.

The energy released by the electric arc is sufficient to melt the constituent material of the contact elements, which not only results in degradation of the metallic parts but also sometimes results in them being welded together, with the consequence of locking the equipment.

In AC applications, arc cut-off is facilitated by the voltage passing through zero. However, certain protection devices must cut off very high currents, which bring about arcs of sufficient energy to damage the contacts.

On the other hand, for DC applications the electric arcs are very stable, especially when the voltage is substantially above 10 volts. One solution for cutting off the arc consists in increasing its length in such a way that it becomes unstable and disappears by itself. For a voltage of 14 volts, a distance of the order of one millimeter is sufficient, whereas for a voltage of 42 volts, particularly when an inductive load is present, this distance may be

several centimeters. This seriously complicates the construction of the cut-off devices and the duration of the arcs created greatly reduces their lifetime.

The problem arises most particularly in the automobile industry, which envisions the use of 42 volt DC circuits for matching the ever increasing number of electrical devices present in cars (up to one hundred motors in a top-of-the-range vehicle). At such voltages, the benefit of limiting the problems associated with arcs becomes paramount.

Thus, the materials of electrical contacts must meet the following three requirements:

- low contact resistance in order to avoid excessive heating when the current is flowing;
- good resistance to welding in the presence of an electric arc; and
- low erosion under the effect of the arc.

To meet these partly contradictory requirements, one solution consists in using pseudo alloys comprising a silver or copper matrix and, inserted into this matrix, a fraction consisting of about 20% by volume of refractory (for example Ni, C, W, WC, CdO, $SnO_2$) particles having a size generally between 1 and 5 microns. The material thus obtained is more resistant to the heat generated by the electric arc. Although constituting a useful solution, this method does not make it possible to limit melting and, because of their repetition, problems of erosion and welding of the contact elements may occur in the short or medium term.

Moreover, when it is a question of producing AC protection devices (circuit breakers) capable of cutting off very high currents, it has been proposed to use auxiliary means to help in extinguishing the arc or preventing it from reigniting, namely pneumatic or electromagnetic blow-out means. It has also been proposed to replace the gas present in the space separating the two contacts with a very stable and therefore not easily ionizable gas, such as $SF_6$. However, all these solutions are complex to implement.

The object of the present invention is therefore to provide an electrical contact material with which it is possible to produce contact elements whose operation

is not impaired either in the short term or the long term by the energy of an electric arc.

More precisely, the contact material with an extinction effect according to the invention comprises a matrix made of conductive metal and an unstable fraction incorporated into this matrix, the unstable fraction having the property of decomposing at a temperature between the operating temperature of the contact and the melting point of the metal, with the release of a gas capable of destabilizing an electric arc.

The invention also relates to a process for manufacturing the material defined above. It essentially consists in:

- providing a blend comprising a conductive metal and an unstable constituent as defined above;
- compacting this blend; and
- forming it according to the intended use.

Other features of the invention will become apparent from the description that follows, which is not accompanied by any drawing.

The contact material according to the invention essentially consists of the following three components:

- a matrix made of conductive metal, generally silver or copper;
- a refractory fraction stable at a temperature above 900°C, which may advantageously be chosen from the following group: CdO, $SnO_2$, ZnO, $Fe_2O_3$, Ni, Fe, W, Mo, C, WC, MgO; and
- an unstable fraction that decomposes at a temperature between 200 and 900°C, releasing a gas capable of cooling the arc, and that may advantageously be chosen from the following group: metal hydrides ($TiH_2$, $ZrH_2$, $MgH_2$) and multi-metal hydrides based on Ti, Zr, Hf, V, Nb, Mg, Ta, Cr, Mo, W, Fe, Co, Ni, La, Y.

When the unstable fraction has released its arc-cooling gas, its decomposition having in general taken place in air, the residue is a metal which, having partly or completely reacted with the oxygen and nitrogen in the air, can completely or partially replace the refractory fraction. Therefore the refractory fraction is

not an essential component of the contact material.

When no refractory fraction is present, the unstable fraction constitutes, by itself, between 5 and 50% of the volume of the contact material.

When a refractory fraction is present, the two fractions constitute between 5 and 50% of the volume of the material, but then the proportion of the unstable fraction is at least 2% by volume.

The material according to the invention may advantageously include, in addition, small amounts of dopants designed to optimize the properties of the material. For example, these dopants are $Bi_2O_3$, CuO or Re.

Pairs of contact elements may be produced using materials of the same composition or of different compositions. In this case, it is possible for only one of the two contacts to contain an unstable fraction.

Thus, the invention proposes an electrical contact material which, under the effect of the heat produced by an electric arc, releases a gas essentially formed from hydrogen when, advantageously and as mentioned above, the decomposed unstable fraction is a hydride. This gas cools and destabilizes the arc, which therefore is rapidly extinguished.

Nevertheless, since the arc has been created a portion of each of the contacts can melt under the effect of its heat, in such a way that they are welded together. If such is the case, given that the release of the gas from the unstable fraction has made the surface of the melted contacts porous, and therefore brittle, the weld between them will be easy to break next time the contacts are opened. This is a major advantage of the material according to the invention.

In general, the process for manufacturing the contact material that has just been described consists, in succession, in:

- providing a blend of the abovementioned base constituents, namely a conductive metal, an unstable fraction and, optionally, a refractory fraction;

- compacting this blend;
- optionally, sintering the part obtained;
- forming the part according to the intended use;
- optionally, applying a final heat treatment to it; and
- if necessary, finishing it off for its use.

According to a first preferred embodiment, the base constituents of the material are in the form of powders which are then dry-blended or wet-blended, or blended using the technique called “mechanical alloying”, which causes welding of the particles together, and then their fracture into smaller particles. These three methods are all well known to those skilled in the art.

The blend obtained is then compacted in the form of a pellet, either by uniaxial cold pressing, or by hot pressing, but at a moderate temperature and optionally under pressurized hydrogen, that is to say under hydrogen temperature and pressure conditions in which the unstable fraction does not decompose, or else by impact compaction (adiabatic compaction method). The resulting part is then sintered at a moderate temperature and optionally under pressurized hydrogen. It should be noted that this operation is optional when the compacting has been carried out at a moderate temperature or by impact compaction. Finally, the part is formed by cold recompaction.

According to a second preferred embodiment, the process repeats the same first steps as the embodiment described above, but this time the blend is compacted by pressing it into a strip. The pressing is carried out uniaxially, cold or at moderate temperature, the resulting part then being sintered at moderate temperature, optionally under pressurized hydrogen. As in the first embodiment, the sintering is not necessary if the pressing has already been carried out at moderate temperature. The part is finally formed by rolling.

According to a third preferred embodiment, the same initial blend is compacted in the form of a billet, either by cold pressing, in isostatic mode, or by pressing at moderate temperature. The resulting part is then sintered, again at moderate temperature and optionally under pressurized hydrogen. The sintering is optional if the pressing has already been carried out at moderate temperature. Finally, the part is formed by extrusion at moderate

temperature into strip or wire. This product is then converted into a contact part by any technique known to those skilled in the art.

According to a fourth embodiment, the process repeats the same first steps as above, but then the blend undergoes cold compaction without sintering. The resulting part is finally formed using one of the techniques already mentioned.

According to a fifth embodiment, the various constituents are again provided in powder form. However, the unstable fraction is not in its final form, but in the form of a precursor, that is to say the metal atoms of the unstable fraction are in the zero oxidation state. For example, the powder is in the form of Ti instead of $TiH_2$, Zr instead of $ZrH_2$, or Mg instead of $MgH_2$. The precursor may be free or alloyed with the matrix. The various powders are then blended, by dry blending, wet blending or by mechanical alloying. The blend is then compacted in the form of a pellet by cold uniaxial pressing, by hot pressing or by impact compaction. The part is then sintered at high temperature, without hydrogen, optionally if the pressing has been carried out hot or by impact compaction, before being subjected, in the hydrogen atmosphere, to a heat treatment for hydriding the precursor of the unstable fraction. Finally, the part is formed by cold recompaction. As a variant, the sintering may be carried out directly in a hydrogen atmosphere, which then avoids the specific hydriding treatment.

According to a sixth embodiment, the same blend as that described in the above embodiment is compacted by cold isostatic pressing, or by hot uniaxial pressing. The part obtained is then either sintered at high temperature, optionally if the pressing has been carried out hot, or sintered in a hydrogen atmosphere, so as to hydride the precursor of the unstable fraction. To do this, it is necessary that the compacted billet be sufficiently porous to allow hydrogen to get right to the center of the part. When the sintering has been carried out at high temperature without hydrogen, the part is formed by high-temperature extrusion before it undergoes a hydriding treatment. When the sintering has been carried out in a hydrogen atmosphere, the part is formed by extrusion at moderate temperature.

According to a seventh embodiment, the same blend as that described in the

previous embodiment is compacted in the form of a strip by cold uniaxial pressing or by hot pressing. The part obtained is then either sintered at high temperature, optionally if the pressing has been carried out hot, or sintered in a hydrogen atmosphere, so as to hydride the precursor of the unstable fraction. The part is formed by rolling before, if necessary, undergoing a hydriding treatment.

According to an eighth embodiment, the various constituents of the material are provided in the form of a bulk alloy containing the precursor of the unstable fraction. The alloy is then melted and cast in the form of a billet or ingot, and then, in the case of a billet, extruded at high temperature, typically at 900°C, or, if it is in the form of an ingot, converted into strip or wire by successive plastic deformation operations (rolling, wire-drawing, hammer swaging, etc.) interspersed by heat treatments, before undergoing the final hydriding.

According to the above eight embodiments, the parts undergo conventional final treatments, for example cutting, forming, polishing, expansion heat treatment.

The various embodiments that have just been described do not constitute an exhaustive list. Other combinations of the various means proposed for each of the steps may optionally be used.

In all the embodiments described, it is also possible to add, during compacting, a thin sublayer, generally of the same composition as the conductive metal used (generally silver or copper), intended to make it easier, subsequently, to carry out the welding and brazing operations that the part may undergo when it is being used.

Of course, the unstable fraction may consist of a blend either of several of the elements proposed above for forming said fraction or of one of these elements, but with a different particle size. Thus, it is possible to obtain various decomposition rates so that the material obtained can operate within an extended range of conditions.

Thus, to summarize, the invention proposes an electrical contact material capable of destabilizing an electric arc occurring between two contact elements, so as not to be impaired in the long term by the effects of the heat released. In addition, the process for manufacturing this material, owing to its great flexibility, makes it possible to produce contact parts in any of the standard forms using the same means of production as used for the current materials.